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METROLOGY GROUP

Instruction Manual

Logarithmic Survey Meter

Model 414

Baird-Atomic, Inc.

33 UNIVERSITY ROAD • CAMBRIDGE 38, MASS.

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THIS INSTRUMENT IS SHIPPED WITH ALL BATTERIES AND SILICA-GEL INSTALLED AT FACTORY.

I. GENERAL DESCRIPTION

The Model 414 Radiation Survey Meter is a portable rate meter which can measure X-ray, gamma, and higher energy beta rays from 3 to 3000 milli-roentgens per hour. It is calibrated logarithmically. This eliminates scale-switching and errors in scale-selection, and provides equal sensitivity at any point on the scale. The speed of response of the meter varies directly as the intensity of the radiation being measured--a safety feature for high readings.

Brief Principle of Operation. The instrument has an ionization chamber and an electrometer tube to amplify and convert to logarithmic plate current the radiation pulses. A meter in the plate circuit of the electrometer tube records the level of radiation. The unit is self-powered with batteries for the ionization chamber, filament of electrometer tube, B plus, and calibration circuit. A switch allows checking by meter of the various battery voltages and of correct calibration.

Specifications:

1. Range: Three decade, logarithmic scale; 3 mr/hr to 3,000 mr/hr
2. Meter: ± 1% movement; 3 1/2" meter with 3.11" scale length; critically damped; specially designed scale markings for easy reading.
3. Accuracy:
   a. Over-all accuracy: within ± 20% of indicated reading anywhere on the scale for radium gamma rays.
   b. Long-term reproducibility: within ± 15% of reading
   c. Deviation from function linearity at any point on scale: within ± 10% of reading
   d. Energy dependency: ± 15% from 80 kev x-ray to 2 mev gammas
4. Beta Window: "Mylar" plastic coated with aluminum; less than 0.9 mg/cm^2; can be covered by a removable 1/8" thick bakelite window cap.
5. Time Constant: Inversely proportional to radiation level; approximately one second at mid-scale reading of 60 mr/hr.
6. Ionization Chamber: 1/8" thick bakelite wall; 3" diameter by 6" long; approximately 600 cc in volume.
7. Battery Life: on continuous duty
   a. Filament batteries: 1,000 hours approx.
   b. B+ battery: 3,000 hours approx.
   c. Bucking current battery: shelf life
   d. Chamber voltage battery: shelf life
8. Battery Complement:
   a. Filament: 3 - 1.3 volt, Mallory RM12R
   b. B+: 1 - 5.2 volt, Mallory TR164
   c. Bucking Current: 1 - 1.3 volt, Mallory RM12R
   d. Chamber: 3 - 22.5 volt, Eveready 505

9. Dessicant Complement: Silica-gel cartridges, Davidson Chemical Company, 42-03-X1090
10. Controls:
    a. Calibration Knob: protected from accidental shift by knob guard
    b. Control Switch: 6 positions:
       Off - filament check - B+ check - chamber voltage check - calibration - read
11. Over-all size: 9 1/2" high x 12" long x 4 1/8" wide
12. Housing: cast aluminum coated with copper
13. Net Weight: 5 lbs including batteries; center of gravity located in handle for easy handling.
14. Shipping Weight: 10 lbs

II. INSTALLATION

The instrument is portable. Operation merely requires proper installation of batteries. The following operations should be done within the shortest possible time in order to prevent excessive moisture from getting into the instrument.

1. Make sure switch is at OFF position.
2. Remove handle by removing the four oval-head screws.
3. Loosen the Phillips head screws which hold battery bars.
4. Remove the two battery bars.
5. Install four Mallory RM-12 1.3V batteries, observing polarities engraved on battery boards.
6. Install one Mallory TR164R 5.2V battery observing polarities on battery board.
7. Install three Eveready 505E hearing-aid 22 1/2V batteries, observing polarities.
8. Install battery bars: slide bars from center of instrument toward the edges with rubber side of battery bars against batteries.
9. Gently tighten screws holding battery bars. Screws should be just tight enough to keep battery bars from sliding off.
10. Mount handle to its original place.

NOTE: During this operation, care should be taken not to allow dust, smoke or moisture to enter the housing.

INSPECTION OR REPLACEMENT OF DESSICANT CARTRIDGE:

1. The dessicant cartridges (Davidson Chemical Co. 42-03-X1090) contain silica gel enclosed in semi-permeable cellophane envelopes. When the cartridges have absorbed a certain quantity of humidity, the crystals enclosed turn pink. The cartridges then should be replaced.
2. To replace the dessicant cartridges: Unscrew the plastic domes, remove old cartridges, insert new cartridges and secure plastic domes.

NOTE: Periodic inspection should be made of these cartridges and immediate replacement is recommended when they turn all pink.

III. A. OPERATION

After the dessicant cartridges have absorbed most of the moisture contained inside the housing at the time of battery replacement, the instrument is ready to operate.

1. Rotate the switch to FIL. V. position and leave at this position for two minutes. Two operations are being performed at this position:
   a. The filament battery condition is being displayed. The meter pointer should go up and stay within the green block marked "B+, Vf".
   b. The tube filament is being warmed up.
2. Rotate switch to "B+V" position. Meter pointer should go up and stay within the green block marked "B+, Vf". This tells the condition of the B+ battery. Observe 30 seconds to see whether the pointer has any tendency toward dropping. Battery is weak if it does and it should then be replaced.
3. Rotate switch to "Chamber V" position. Pointer should go up and stay within the green block marked "Vc". This tells condition of the chamber batteries. Observe 30 seconds to see whether the pointer has any tendency toward dropping. Battery is weak if it does and it should then be replaced.
4. Rotate the switch to CAL position, and adjust CAL knob so that the pointer falls on the red mark at 30 mr/hr. Since this operation directly affects the reading accuracy, it should be set as precisely as possible.
5. Rotate the switch to READ. The pointer should settle down on the zero block. Instrument is now ready for use.
6. Slide off the window cap when β-emanation is measured.
7. Window cap may be either on or off when measuring Gamma or X-rays.
8. Leave instrument at READ position for intermittent operation. This position requires the least drain on batteries.
9. To insure accuracy, calibration (step #4 above) should be checked periodically. If instrument is used continually, this requirement becomes less important as times goes on.

NOTES:

a. Battery conditions should be checked periodically.
b. Any abrupt change of CAL reading from the red mark is usually a good indication of battery exhaustion. Check by switching from CHAMBER V to B+V to FIL V.
c. It is not necessary to hold two minutes at FIL V position when the instrument is switched off.
d. Whenever the instrument is switched on from OFF position, it is always necessary to allow two minutes warm-up time at FIL V position before switching to B+V position.
e. When switching from READ to CAL, the pointer usually hesitates a couple of seconds before it rises. This is characteristic of the instrument and should not cause any alarm.

B. CALIBRATION

The internal calibrating adjustments "Cal set" & "Slope set" have been fixed at the factory. A complete calibration requires the following steps:

a. Make sure that the atmosphere inside the instrument has been mostly dehydrated. If instrument has been idling without dehydrating for an extended period of time, silica-gel cartridges should be first used for drying as described above in Section II.

b. Since slight short-time drift exists in the electrometer tube, the instrument should be left at "READ" position for a while for stabilization. A period of one hour or more is recommended. This precaution affords easier and more accurate calibration.

c. The ionization chamber is practically "directional-independent" in the horizontal plane for a spread of 180°. However, for reason of uniformity, our instruments were calibrated at the factory with the axis of the cylindrical chamber directly pointing at the source on the same horizontal plane. (With end cover off.)

d. Two known levels of radioactive flux are required for calibration. They can be higher energy gamma rays or X-rays. It is suggested that calibration points at fluxes of 15 and 1500 MR/hr be used.

e. After the stabilization (suggested in "B"), place the instrument in such a position that the source is on the axis of the ionization chamber. Remove the screws covering the potentiometers marked "Slope" (R8) and "Cal. Set" (R3).

f. With the switch at "Read" position, the following steps should be used to calibrate the instrument:
   1. With the source at 15 MR/hr, adjust the "Cal" potentiometer on the top of the instrument to read 15 MR/hr on the meter.
   2. Switch the source to 1500 MR/hr, adjust the internal "Slope" potentiometer to read 1500 MR/hr.
   3. Switch the source back to 15 MR/hr, adjust the "Cal" potentiometer again to read 15 MR/hr.
   4. Switch the source to 1500 MR/hr, readjust the "Slope" potentiometer to 1500 MR/hr.
   5. Repeat the above process until the meter reads 15 and 1500 without adjusting either potentiometer.

NOTE: Allow enough time for meter needle to settle down before taking reading or adjusting the potentiometer.

g. After calibration of Step F is completed, remove the source completely. Then turn the switch to "Cal" position.

h. Adjust the internal potentiometer marked "Cal Set" to read 30 MR/hr on the red mark.

j. Install the two screws covering these internal adjustments to prevent excessive moisture from entering the unit.

k. Turn the switch to "Read" position and the instrument is ready for use.

IV. CIRCUIT DESCRIPTION

The Model 414 Radiation Survey Meter contains an ionization chamber which feeds an electrometer tube. This tube responds logarithmically to input signals which it also amplifies sufficiently to actuate a microammeter (calibrated in milli-roentgens per hour) in the plate circuit. A variable resistor R8, shunting part of the current around the meter, varies the slope of the response curve. The dynamic impedance of the grid circuit is inversely proportional to the grid current. Consequently, the speed of response of the instrument varies directly with the level of radiation applied.

Because of the small dynamic range of the grid voltage, a small but important variation in the voltage between grid and cathode (the so-called "contact potential") would change the meter reading unless compensated for. A battery (B5) supplies an adjustable amount of current (varied by R10, 'Cal') to "buck" or nullify the effect of the meter on this voltage variation.

The batteries which power the ionization chamber can be switched to supply a calibrating current across Hi-meg resistor, R1. Contact potential varies with time, so this calibration has to be repeated occasionally. Since the slope shift is not excessive for the specified 20% over-all accuracy of the instrument, calibration is set at only one point.

V. MAINTENANCE

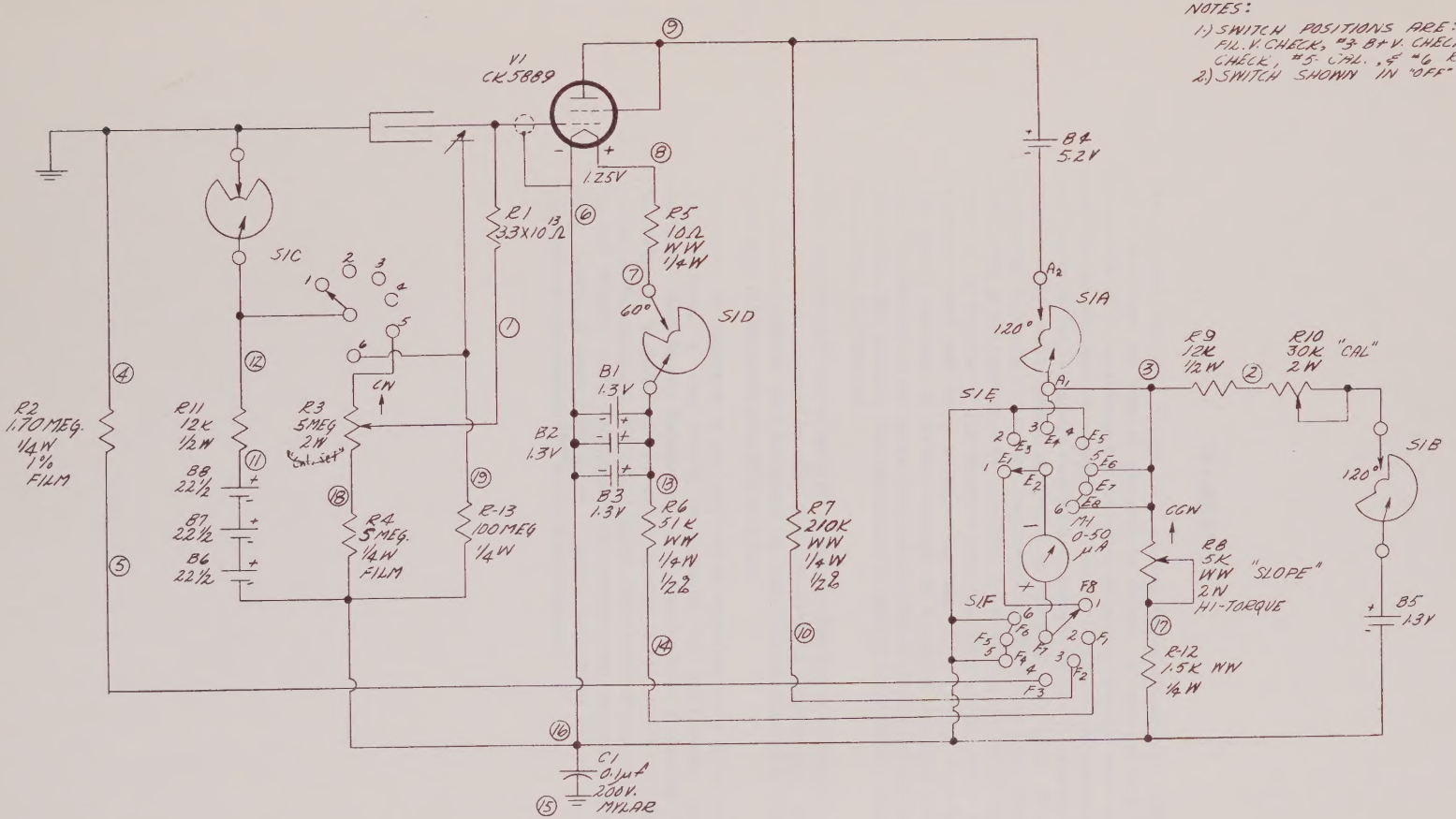
1. Since the silica-gel cartridges are used to absorb the moisture inside the instrument, they should be inspected periodically. When they turn completely pink, it indicates that they are fully saturated. Immediate replacement is recommended.
   If so desired, these cartridges can be re-used after they are baked dry in an oven set at a temperature of 65 - 70°C.
2. Regardless of whether or not the instrument is in use, it is recommended that the batteries be inspected for possible corrosion every 3 - 6 months. If trace of corrosion is found, they should be taken out and cleaned with lint-free cloth. Battery contacts should be cleaned likewise. Batteries are still useable if their voltages check properly in the unit.
3. Whenever the instrument is opened for any reason, the following steps should be strictly observed:
   a. Leave the instrument open for as short a period as possible to prevent an unnecessarily large amount of moisture getting into it.
   b. Care should be taken not to allow any dust, cigarette smoke, or excessive moisture to get into the instrument.
   c. Since all points in the circuit including the battery contacts are approximately 67 1/2-volts above case, the 22 1/2-volt batteries should be the first to be taken out after removing the handle. Conversely, when the batteries are being installed, the 22 1/2-volt ones should be the last to be put in.

   Failure to observe these rules may result in damaging the components.

414 Parts List

Symbol Designation	Description	B-A No.
B1	Battery, mercury, Mallory RM12, 1.3V, 3600 mah., 0.625" x 2" long	
B2	Battery, mercury, Mallory RM12, 1.3V, 3600 mah., 0.625" x 2" long	
B3	Battery, mercury, Mallory RM12, 1.3V, 3600 mah., 0.625" x 2" long	
B4	Battery, mercury, Mallory 164R, 5.2V, 500 mah. 0.625" x 1 3/4" long	
B5	Same as B1	
B6	Battery, Eveready Minimax, 22 1/2V, National Carbon Co. #505	
B7	Battery, Eveready Minimax, 22 1/2V, National Carbon Co. #505	
B8	Battery, Eveready Minimax, 22 1/2V, National Carbon Co. #505	
C1	0.1 μf, 200V, 10%, mylar (Goodall 421, 0.430 x 25/32")	CP104-17
M1	Meter (0-50 μa, specially damped)	MT-6A
R1	$3.3 \times 10^{13}\Omega$ ("Hi-Meg Resistor"), 10% (Victoreen #245)	RF3312-1
R2	1.70 Meg, 1/4W, 1%, film (Allies Prod. APT -1/4)	RF175-2
R3	5 meg, 2W, carbon pot.	RV505-3
R4	10 meg, 1/4W, 1%, film	RF106-3
R5	10Ω, 1/4W, 1%, wirewound	RW100-2
R6	51K, 1/4W, 1/2%, wirewound	RW513-1
R7	210K, 1/4W, 1/2%, wirewound	RW214-1
R8	5K, 2W, wirewound pot. (Hi-torque)	RA-502-3
R9	12K, 1/2W, 5%, carbon	RCE123-J
R10	30K, 1W, carbon pot. (High Torque)	RA 303-1A
R11	12K, 1/2W, 5%, carbon	RCE 123-J
R12	1.5K, 1/4W, 1%, wirewound	RW 152-1
R13	100 Meg, 1/4W, 10%, film	RF 107-1
S1	Switch, rotary, 3 wafers	SR-19
V1	CK 5889 (aged and tested by B.A.)	

NOTES:
1.) SWITCH POSITIONS ARE: "1-OFF, "2-FIL.V. CHECK, "3-B+V. CHECK, "4-CHAMBER V. CHECK, "5-CAL., & "6 READ.
2.) SWITCH SHOWN IN "OFF" POSITION.



SCHEMATIC
SINGLE TUBE LOGARITHMIC SURVEY METER
MODEL 414

REV.
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WARRANTY

Baird-Atomic, Inc. (the "Company"), warrants this equipment for a period of 1 year from the date of shipment as follows: it warrants that all equipment of its manufacture is free from defects in material and workmanship at the time of shipment. If within 1 year of shipment any equipment of the Company's manufacture develops defects in material or workmanship under normal conditions of operation, the buyer of the equipment may return it to the Company within 30 days of such failure, for repairs at the expense of the Company, including the expense of shipment, or in the case of any defective part may return such part to the Company which will repair or replace the same at its expense, including the cost of shipment. A further warranty of 1 year on the same terms shall be applicable to any part so repaired or replaced. Except for Dekatron glow tubes, this warranty does not extend to stock components not manufactured by the Company.

The Company shall not be liable for damage or destruction of instruments during delivery or caused by other than employees of Baird-Atomic, Inc.; in any event, liability shall not exceed the cost of replacement of defective parts upon prompt notification of such defect.

For return of equipment or any part thereof under the terms of the foregoing warranty a letter should be forwarded to Baird-Atomic, Inc., Attention: Sales Service Department, 33 University Road, Cambridge 38, Massachusetts. It should state owner's name and address; model and serial number of the equipment; the order number, under which it was purchased; the date of failure and a description of the circumstances surrounding same. Upon receipt of such information, shipping instructions for return of equipment or parts thereof will be forwarded promptly.

Baird-Atomic, Inc.
33 UNIVERSITY RD., CAMBRIDGE 38, MASS.